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CLAIMS

WHAT IS CLAIMED IS:

1. Method of non-destructively marking an object containing a radiation sensitive material with a detectable predefined pattern using laser generated radiation, said method comprising:

selecting said object, said object including an object substrate having a markingly effective amount of said radiation sensitive material in a region that is generally visible, said radiation sensitive material requiring an minimum level of radiation flux to effect said marking;

selecting a digital micro-mirror device, said digital micro-mirror device having a mirrored face and being capable of tolerating a maximum level of radiation flux, said maximum level being less than said minimum level;

adjusting said mirrored face to reflect said detectable predefined pattern;

generating a pulse of radiation, said pulse of radiation being coherent and having a first cross-sectional area, the level of said radiation flux in said first cross-sectional area being greater than said maximum level;

expanding the cross-sectional area of said pulse of radiation to produce an expanded pulse of radiation, the level of said radiation flux in said expanded pulse of radiation being no greater than said maximum level;

impinging said expanded pulse of radiation on said mirrored surface and allowing said mirrored surface to reflect said expanded pulse of radiation in a patterned pulse of radiation;

condensing said patterned pulse of radiation to produce a condensed patterned pulse of radiation, the level of radiation flux in said condensed patterned pulse of radiation being at least as great as said minimum level; and

projecting said condensed patterned pulse of radiation on said object substrate and allowing said detectable predefined pattern to form in said radiation sensitive material.

2. A method of claim 1 including selecting a said digital micro-mirror device that is capable of tolerating a maximum level of radiation flux that is less than approximately half said minimum level.

3. A method of claim 1 including serially generating at least a first and a second said pulse of radiation, and adjusting said mirrored face to reflect different detectable predefined patterns between said first and second pulses of radiation.

4. A method of claim 1 wherein said condensing includes adjusting said mirrored face to condense said patterned pulse of radiation.

5. A method of claim 1 including selecting a said radiation sensitive material that is adapted to absorbing at least 10 times more of said radiation than said object substrate.

6. Method of marking titanium dioxide containing object substrate with a detectable predefined pattern using coherent ultraviolet radiation, said method comprising:

generating a pulse of coherent ultraviolet radiation having a first footprint, said coherent ultraviolet radiation having a first flux density within said first footprint;

expanding said pulse of coherent ultraviolet radiation to a second footprint having a second flux density;

projecting said second footprint on a mirrored face of a digital micro-mirror device, and allowing said mirrored face to reflect said coherent ultraviolet radiation in said detectable predefined pattern to produce a reflected footprint;

condensing said reflected footprint to produce a marking footprint having a third flux density, said first and third flux densities being greater than said digital micro-mirror device is capable of withstanding, and said third flux density being at least sufficient to cause the color of said titanium dioxide to change, and less than a level at which visible damage occurs to said object substrate; and

projecting said marking footprint on said object substrate and allowing said detectable predefined pattern to form in said titanium dioxide.

7. A method of claim 6 including selecting an object substrate that absorbs less than approximately one fifth as much of said coherent ultraviolet radiation as said titanium dioxide.

8. A method of claim 6 including condensing said reflected footprint so that said third flux density is greater than said first flux density.

9. Method of marking titanium dioxide containing object substrates with a detectable predefined pattern using coherent ultraviolet energy, said method comprising:

projecting a series of pulses of coherent ultraviolet energy having a first level of flux density onto a mirrored face of a digital micro-mirror device, said mirrored face being composed of a plurality of individual mirror elements, said individual mirror elements being individually controllable, tiltable, and spaced apart, a bypass portion of said coherent ultraviolet energy having said first level of flux density projecting between said individual mirror elements and impinging upon a base behind said individual mirror elements;

preventing said bypass portion from damaging or disrupting said base; and

allowing said mirrored face to reflect said coherent ultraviolet energy in said detectable predefined patterns;

adjusting said mirrored face between at least some of said pulses and allowing said mirrored face to reflect said pulses of coherent ultraviolet energy in different ones of said detectable predefined patterns to produce a series of reflected footprints;

condensing said reflected footprints to produce a series of marking footprints having a second level of flux density, said second level of flux density being at least sufficient to cause said titanium dioxide to change color, and less than a level at which visible damage occurs to said object substrates;

preventing said bypass portion from being reflected within said marking footprints; and

projecting said marking footprints on said object substrates and allowing said detectable predefined pattern to form in said titanium dioxide.

10. A method of marking according to claim 9 wherein said preventing includes reflecting at least a part of said bypass portion away from said base.

11. A method of marking according to claim 9 wherein said preventing includes absorbing at least a part of said bypass portion in said base.

12. A method of marking according to claim 9 wherein said preventing includes conducting at least a part of said bypass portion away from said base.

13. A method of marking according to claim 9 including selecting a said object substrate that is capable of absorbing less than approximately one fifth as much of said coherent ultraviolet energy as said titanium dioxide.

14. Method of making a plurality of markings with detectable predefined patterns on titanium dioxide containing object substrates using coherent ultraviolet energy, said method comprising:

projecting a series of pulses of coherent ultraviolet energy onto a mirrored face of a digital micro-mirror device, each of said pulses having a first level of flux density;

adjusting said mirrored face between at least some of said pulses and allowing said mirrored face to reflect said pulses of coherent ultraviolet energy in different ones of said detectable predefined patterns to produce a series of reflected footprints, said first level of flux density being less than a damaging level at which said digital micro-mirror device is damaged or disrupted;

condensing said reflected footprints to produce marking footprints having a second level of flux density, said second level of flux density being greater than said damaging level, at least sufficient to cause said titanium dioxide to change color, and less than a level at which visible damage occurs to said object substrates;

projecting said marking footprints on said object substrates and allowing said detectable predefined patterns to form in said titanium dioxide; and

preventing said marking footprints from damaging said object substrates by selecting object substrates that are adapted to absorbing less than approximately one tenth as much of said coherent ultraviolet energy as said titanium dioxide.

15. Method of non-destructively marking object substrates containing a radiation sensitive material with detectable predefined patterns using coherent energy, said method comprising:

projecting a series of pulses of coherent energy having a first level of flux density onto a mirrored face of a digital micro-mirror device, said mirrored face being composed of a plurality of individual mirror elements, said individual mirror elements being individually controllable, tiltable, and spaced apart, a bypass portion of said coherent ultraviolet energy having said first level of flux density projecting between said individual mirror elements and impinging upon a mirror support base behind said individual mirror elements, said first level of flux density being less than a damaging level at which said support base is damaged or disrupted, and allowing said mirrored face to reflect said coherent energy in said detectable predefined patterns;

adjusting said mirrored face between at least some of said pulses and allowing said mirrored face to reflect said pulses of coherent energy in different ones of said detectable predefined patterns to produce a series of reflected footprints;

condensing said reflected footprints to produce a series of marking footprints having a second level of flux density, said second level of flux density being greater than said damaging level, at least sufficient to cause said radiation sensitive material to change color, and less than a level at which visible damage occurs to said object substrates;

preventing said bypass portion from being reflected into said marking footprints, and dissipating said bypass portion of said coherent energy from said mirror support base;

projecting said marking footprints on said object substrates and allowing said detectable predefined patterns to form in said radiation sensitive material; and

preventing said marking footprints from damaging said object substrates by selecting object substrates that are adapted to absorbing less than approximately one tenth as much of said coherent ultraviolet energy as said radiation sensitive material.

16. Method of marking radiation sensitive material containing object substrate with a detectable predefined pattern using coherent radiation, said method comprising:

generating a pulse of coherent radiation having a first footprint, said coherent radiation having a first flux density within said first footprint;

expanding said pulse of coherent radiation to a second footprint having a second flux density;

projecting said second footprint on a mirrored face of a digital micro-mirror device, and allowing said mirrored face to reflect said coherent radiation in said detectable predefined pattern to produce a reflected footprint;

condensing said reflected footprint to produce a marking footprint having a third flux density, said first and third flux densities being greater than said digital micro-mirror device is capable of withstanding, and said third flux density being at least sufficient to cause the color of said radiation sensitive material to change, and less than a level at which visible damage occurs to said object substrate;

minimizing the level of said third flux density that is required to cause said color change; and

projecting said marking footprint on said object substrate and allowing said detectable predefined pattern to form in said radiation sensitive material.

17. Method of marking of claim 16 wherein said minimizing includes utilizing from about 0.5 to about 5 weight percent of said radiation sensitive material in said object substrate.

18. Method of marking of claim 16 wherein said minimizing includes selecting a said radiation sensitive material having an average particle size of less than approximately 10 microns.

19. Method of marking of claim 16 wherein said minimizing includes selecting a said radiation sensitive material having an average particle size of less than approximately 5 microns, and utilizing from about 0.5 to about 2 weight percent of said radiation sensitive material in said object substrate.

20. Method of marking of claim 16 wherein said minimizing includes selecting titanium dioxide as said radiation sensitive material and coherent ultraviolet light as said coherent energy, said titanium dioxide having an average particle size of less than approximately 10 microns, and utilizing from about 0.5 to about 5 weight percent of said titanium dioxide in said object substrate.